GLACIATION IN THE TELLURIDE QUADRANGLE, COLORADO

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PART II

VALLEY OF BRIDAL VEIL CREEK

In elevation this valley ranges from 10,300 feet at the point where Bridal Veil Creek falls into the cirquelike head of the San Miguel valley, to a little more than 13,500 feet, the elevation of the highest peaks on its margin. Above 12,000 feet in elevation it is a broad, flat-bottomed basin a mile or more in width, bounded by cliff walls rising for the most part not more than 200 or 300 feet in height. On this broad, flattened bottom a number of small lakes and ponds occur, lying in rock basins.

Throughout the extreme southwestern part, rock ridges and knobs with rounded surface give character to the topography. Some of the ridges are as much as 50 to 75 feet in height; for the most part, however, the relief is not so great. Some of the rounded surfaces show striae; but in the great majority of cases the general rounded surface is either roughened by unequal erosion or is covered with a layer of small angular fragments, which, in the case of the igneous rocks of this region, easily results from change of temperature. The weathering accomplished since the disappearance of the ice has produced enough soil to support a flora which in the summer months gives a more or less pronounced green color to much of the bottom of the basin.

The south-central part of the basin has a series of tributaries draining numerous small lakes, and flowing north of east to the main stream. Each of these tributaries occupies a level respectively higher than the one next in order to the north, producing in the bottom of the valley the appearance of a series of terraces extending in a direction slightly south of west to north of east.

In the south-central and southeastern part of the basin large angular bowlders up to 15 feet in diameter are scattered over an area of half a square mile or more. These bowlders do not appear to be a part of the talus slope which lies just at the base of the precipitous rock wall which bounds the basin, but, from their somewhat uniform distribution and lack of gradation in size as distance from the cliff face increases, seem to be fragments carried to their present position by the ice. Below about 12,000 feet in elevation the main valley is comparatively narrow, and U-shaped in cross-section.

The channel of the stream in places consists of a narrow gorge 10 to 20 feet deep in the bed rock; in other places it occupies the bottom of the U-shaped cross-section, giving no evidence of having lowered its bed appreciably since the withdrawal of the ice. The amount of post-glacial erosion by the stream may, therefore, be stated as 10 to 20 feet, in the most favorable locations.

The valley is in general well cleaned out; *roches moutonnées*, with abundant striae, are found at many points, the striae being in general approximately parallel to the course of the stream. Some striated surfaces are found on the under side of overhanging ledges which project one or two feet from a nearly vertical cliff face. At about 11,000 feet in elevation, near the trail east of the stream, a striated groove occurs in the nearly perpendicular wall of rock forming the side of the valley. At elevation about 10,700 feet, near the stream, and again a little farther southeast at 11,000 feet, near the trail, pot holes were observed. Each is on the north side of a steep, smooth face of rock in place. The location is such as would result if rock in which a perfect pot hole exists were worn off diagonally across the pot hole, leaving on the steep slope only a trace of the top, while the bottom, still complete, remained wholly back of the sloping face.

Bridal Veil basin has the following tributary basins: (*a*) on the east, (1) East basin, (2) Mud Lake basin, and (3) Gray's basin; (*b*) on the west, (1) Jackass basin, and (2) Silver Lake basin.

East basin.—This basin, above 12,300 feet in elevation, has a comparatively flat bottom and contains a lake lying in a rock basin, which has been converted into a reservoir, increasing its size until

it now has a diameter of nearly half a mile. Northeast of the lake the talus slopes come down to the water's edge; on the southwest, steep, bare slopes of rock in place extend beneath the surface of the water. All along the trail leading into the basin, near the stream, *roches moutonnées* occur. The lake is reported to be 400 feet deep 300 yards from the lower margin; no means were at hand by which to verify or disprove the report.

Mud Lake basin.—This basin is somewhat smaller than East basin. It contains a lake about one-fourth of a mile long and half as broad. An island in this lake, as well as the rock in place on the north side for about 75 feet above the water, shows the rounded outlines of *roches moutonnées*, but no distinct grooves or striae were observed above elevation 12,100 feet. At the head of the basin to the southeast are some rounded knobs of rock in place; but at intervals over the surface angular rock fragments up to 12 feet in diameter appear, partly buried in soil which in the summer is covered with low plants. Beyond this area are the bare talus slopes at the foot of the precipitous bounding walls.

Gray's basin.—Gray's basin is still smaller than Mud Lake basin, and the elevation of its floor is also slightly less, being at 11,900 feet and over. Some rounded, projecting knobs of rock in place occur, but much of the bottom of the basin has enough soil to support a scanty growth of vegetation. In the southeast part of the basin a small rock stream lies at the foot of the talus slope.

Jackass basin and Silver Lake basin.—These basins are characterized by the rounded forms of *roches moutonnées*, and talus slopes sufficiently weathered to support a low alpine flora. Silver Lake basin contains a small lake and has bounding walls less high than the other basins of the Bridal Veil system.

The maximum thickness of ice in the main valley of Bridal Veil Creek was probably not less than 1,200 feet; in the tributary basins, from 200 to 400 feet.

DEER TRAIL BASIN

This basin is a small hanging valley lying more than 1,500 feet above the San Miguel River. Owing to its small size, and its elevation which is on an average perhaps 500 feet less than the

basins tributary to Bridal Veil Creek, the action of the ice was less vigorous. It is like other basins, however, in its flattened profile, in its increased width above the point where it joins the main valley, and in its precipitous bounding walls rising above considerable accumulations of talus. The thickness of ice here was probably from 100 to 300 feet.

VALLEY OF BEAR CREEK

This valley is double headed, and ice from both heads and from La Junta basin on the east united to form the Bear Creek Glacier, about four miles in length. The gradient of the valley, especially toward its head, is steep, locally as much as 1,000 feet per mile. The descent is by a series of precipices. Seen from below (lee side), say from the mill of the Nellie Mine, the valley shows little evidence of glaciation; but seen from above (stoss side), the projecting bosses of rock, and the lower slopes of the valley are obviously smoothed and worn; striae parallel with the course of the valley occur at 9,000 feet elevation. The narrow, deep valley below the upper tributaries is in contrast with the wider and more open basins above. The thickness of the ice which occupied this valley was, at the maximum, more than 1,000 feet.

BASIN EAST OF SAN JOAQUIN RIDGE

The westward-facing slope of Wasatch Mountain shows much talus, and the effect of the ice action is not conspicuous. The eastern part of the basin shows rounded domes of rock of the general form of *roches moutonnées*, but their surfaces are covered with broken rock, and positive signs of glaciation are not evident. Farther west, near the San Joaquin ridge, there are distinct signs of glaciation in the form of *roches moutonnées*, and several ponds in rock basins. The eastern face of the San Joaquin ridge indicates that the thickness of the ice here was not less than 300 feet. The serrate crest of the ridge is in striking contrast with the topography below.

LENA BASIN

Both this basin and its counterpart just west of the base of the San Joaquin ridge are glacial cirques. Both show *roches moutonnées*

in their bottoms, and both have steep descents to the valley below. There is much talus at the bases of the surrounding slopes.

VALLEY OF LAKE FORK

The term Lake Fork is sometimes used to designate that part of the tributary of the San Miguel River from the south which lies above the point of junction with Howard Fork; while that part from the mouth of Howard Fork to the San Miguel River is called South Fork. In this paper, however, the terms lower valley of Lake Fork, and upper valley of Lake Fork, are used to designate, respectively, the portion below and the portion above the mouth of Howard Fork.

LOWER VALLEY OF LAKE FORK

Glacial ice coming down Lake Fork to the valley of the San Miguel not only filled the lower valley of Lake Fork, but spread eastward over the edge of the mesa to a distance of a mile or more from the stream, and together with the glacier in the valley of Bilk Creek entirely covered the mesa between Lake Fork and Bilk Creek for a distance of more than three and one-half miles from the San Miguel River.

The surface of the glacial drift on this mesa is highest toward the northern end, being at a maximum more than 200 feet higher than the outcropping bed rock at the mesa's edge; the surface is lowest just west of the mouth of Turkey Creek, where the drift forms but a thin covering. The ice from Lake Fork passed over the mesa at this point into the valley of Bilk Creek, as is shown by glacial striae on bed rock at the west edge of the mesa, bearing N. 17° W. to N. 24° W. Striae on bed rock at the east edge of the mesa, opposite the mouth of Turkey Creek, vary in direction from N. 3° W. to N. 16° E., the direction of a considerable number being, therefore, approximately parallel to the course of Lake Fork.

The drift on the mesa between Lake Fork and Bilk Creek is arranged in the form of ridges. The highest part of the deposit consists of a ridge about half a mile in length, extending in an approximately north-south direction with a very steep western slope. Southward from this, the ridges have a general northeast-southwest trend, changing at the northeast end to a more northerly

direction. Between these ridges the surface of the deposit is uneven, hummocky, and including kettles occupied in part by small ponds. But although the topography is irregular and uneven, yet the longer dimensions of both the kettles and the elevations are in general parallel to the ridges. The material of the drift on this mesa includes a variety of rocks such as are common to the region; striated bowlders occur at numerous points. The ridges trending northeast-southwest are believed to be due primarily to the action of ice which occupied the valley of Lake Fork; that is, they represent successive positions of the edge of the Lake Fork Glacier as it was finally withdrawing from the mesa, and are, therefore, to be classed as recessional moraines. The north-south ridge near the northern end of the mesa, with its steep western slope, indicates that it, too, was deposited by a glacial sheet from the east. Southward from the lowest part of the mesa as referred to above, the topography is uneven, and not marked by distinct ridges except for a prominent medial moraine three-fourths of a mile long extending from the point of junction of the Bilk Creek and Lake Fork glaciers down to an elevation of about 9,400 feet.

East of Lake Fork, between the San Miguel River and Turkey Creek, the surface of the drift is more or less rough or ridged, the dominant trend of these ridges being parallel to the valley of Lake Fork. The most prominent ridge extends from Vance Creek to Turkey Creek near the eastern edge of the drift, reaching an elevation of more than 9,500 feet at its highest point. North of Vance Creek, while the irregularities of the surface of the drift show distinctly linear arrangement, the ridges are neither so prominent nor so persistent as on the mesa west of Lake Fork.

Southward from Turkey Creek on the east side of the valley for more than two and one-half miles, the topography is wholly irregular and confused. The change in arrangement of the drift is partly due to the greater steepness of the slope on which it lies. From the San Miguel valley to Turkey Creek on the east side of Lake Fork, sedimentary rocks outcrop along the east wall of the valley in a precipitous face below the comparatively level drift-covered area above; but south from Turkey Creek, the sedimentary series

has been worn away to a steep, irregular slope, affording lodgment for glacial débris in greater or less amounts, so that the whole eastern side of the valley from the stream to the eastern limit of the drift presents a steep, irregular surface, with but little change in slope at the elevation corresponding to the edge of the mesa farther north. Landsliding within this area has been noted by Cross;[1] such action is clearly responsible, in part, for the irregular, hummocky topography.

On the west side of Lake Fork, the precipitous face of the sedimentary rocks outcropping below the edge of the mesa extends from the valley of the San Miguel River to about one mile south of the mouth of Turkey Creek. From this point southward for about two miles to the precipice formed by the diorite-monzonite intrusion northeast of Sunshine Mountain, the west slope of the valley, like the eastern, is rough, irregular, and steep, but without precipitous outcrops of rock in place. Unlike the eastern side, however, there is much less glacial débris evident, though rounded pebbles and bowlders, some of them striated, occur at frequent intervals.

In cross-section, the valley of Lake Fork changes from a flat-bottomed, U-shaped form below the mouth of Turkey Creek, to a broadly open, V-shaped form two miles below the mouth of Howard Fork. In general, bed rock in the bottom of the valley is covered with rock waste in the form of alluvium, alluvial fans, or morainal deposits. The alluvial fans are numerous, but comparatively small. Distinct morainal deposits occur only at and a little above the mouth of Turkey Creek—a small recessional moraine, and a fragment of a lateral moraine, respectively.

On the right side of the valley, opposite the junction of Howard Fork with the upper valley of Lake Fork, the drift is found in the form of a well-marked ridge 200 to 300 feet higher than at points above or below. This is clearly another instance of the effect of ice crowding up on the side of a valley opposite to the entrance of a tributary glacier.

The maximum thickness of ice in the lower valley of Lake Fork was about 1,200 feet.

[1] *Telluride Folio*, p. 11.

CIRQUE NORTHEAST OF SUNSHINE MOUNTAIN

The only valley on the west side of the lower valley of Lake Fork which was occupied by a tributary glacier was that one heading in the cirque northeast of Sunshine Mountain. This cirque has practically no exposures of bed rock in its bottom, since the shale which constitutes the underlying formation here weathers readily. In the lower part of the cirque, at an elevation of about 11,000 feet, the slope of the bottom averages about 12°; at 11,300 feet, 20° to 25°; back of this are steep slopes of talus, and above the talus the nearly perpendicular walls of the Telluride formation and igneous rock.

VALLEY OF HOWARD FORK

Howard Fork has but two tributaries that were occupied by glaciers in the more recent epoch, viz., Swamp Canyon and Waterfall Creek. On all sides of Swamp Canyon and its tributaries are found the usual abundant talus accumulations and nearly perpendicular bounding walls. At an elevation of about 11,500 feet, both in the main valley and in the tributary valley on the west, the rounded, smoothed outlines of *roches moutonnées* appear. Striated bowlders were found near the western tributary at an elevation of 11,200 feet. In the lower part of its course the valley shows but little outcrop of rock in place. The maximum thickness of ice in Swamp Canyon was probably from 500 to 800 feet.

The valley of Waterfall Creek has numerous *roches moutonnées* above 11,000 feet in elevation, with striae in some places approximately parallel to the direction of the stream. On the west side of the stream just below the last tributary valley, drift with striated bowlders occurs at 10,750 and at 10,900 feet in elevation. Long talus slopes and cliffs with nearly perpendicular faces form the boundary of the well-cleaned-out valley.

The eastern end of the valley of Howard Fork toward Ophir Pass closely resembles Swamp Canyon in its main features. In the bottom near the stream is a narrow, flattened area, containing a few small ponds; higher up, talus is abundant. The rounded points of exposed rock in place in Ophir Pass indicate that glacial ice was continuous from the valley of Howard Fork over the divide to the east.

Except for deposits about the village of Ophir and near the mouth of Swamp Canyon, the valley of Howard Fork contains but little glacial débris; and of the deposits which may properly be classed as heavy drift that on the north side of the stream near Ophir is partially covered by débris derived from the gullies and ravines cut in the steep southward-facing valley slope. This débris at a short distance north of the stream becomes at the surface at least a true alluvial deposit in the form of a series of alluvial fans, confluent at their lateral edges. The most conspicuous of these fans is that upon which the village of Ophir is built. It has a width (east-west) of about three-fourths of a mile, and its apex is about 400 feet above the main stream at the lower part of Staatsburg Gulch.

In the lower part of the valley near Ophir Station and for a short distance to the east, the valley has the U-shape typical of glaciated valleys, rock in place outcrops at numerous points, and both the rock on the bottom and that on the sides of the valley 200 to 300 feet or more above the stream is rounded, polished, and striated. Eastward from Ophir Station, the entire southward-facing slope of the valley affords but little direct evidence of glaciation; it is furrowed with gullies of sharp V-shaped cross-section down to 10,500 or 11,000 feet in elevation; below this elevation the valleys and ridges are not prominent on the slope. The appearance of a more uniform topography in this lower part is aided by the growth of aspen which is present in some places, and by the alluvial fans which extend across the flattened bottom.

Deposits apparently glacial occur three-fourths of a mile northwest of Ophir village at 10,200 and 10,500 feet in elevation, respectively. On the south side of the valley less than half a mile east of Waterfall Creek, glacial débris with striated bowlders occurs up to about 10,350 feet. Again, on the south side of the stream and west of Swamp Canyon, the surface is covered with glacial drift up to about 11,000 feet. In part it lies in irregular hills, in the form of ridges or benches. This drift includes bowlders in variety, some of them well striated.

The thickness of the ice in the lower part of Howard Fork was probably about 1,000 feet.

UPPER VALLEY OF LAKE FORK

The upper valley of Lake Fork drains a valley proportionately much broader than the other glaciated valleys of the region. As a consequence of its greater width, the action of the ice was less vigorous, and much glacial débris remains. At its maximum a glacier as much as 1,000 feet in thickness moved northward from this valley to join that coming from Howard Fork, as shown by

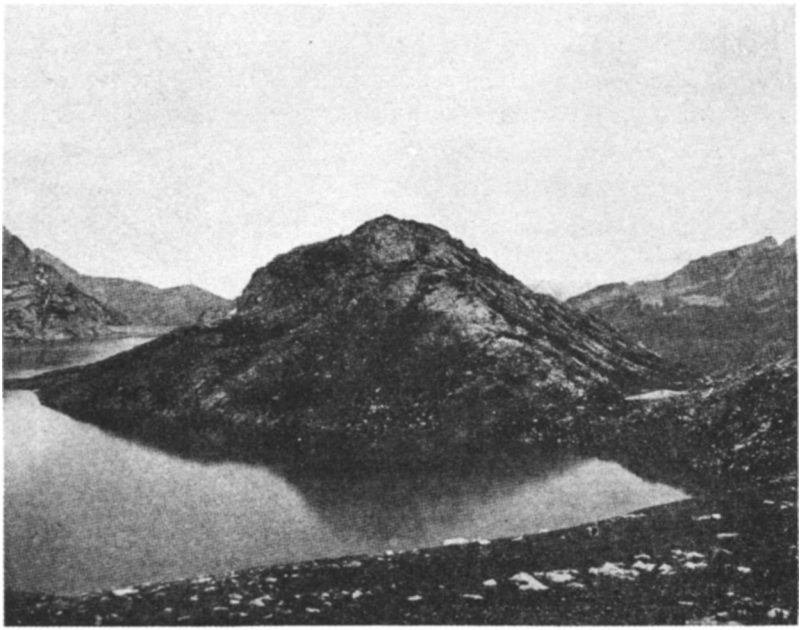

FIG. 5.—Point below small lake at 11,600 to 11,700 feet, four miles southeast of Trout Lake. Glacial ice passed over this point.

glacial striae on rock in place on the east side at 10,000 feet elevation near the Terrible Mine, glacial débris on the same slope 100 to 200 feet higher, and similar deposits on the west side where the edge of the ice crowded up on the north side of the valley of Wilson Creek, at an elevation of 9,800 to 9,900 feet.

That part of the main valley lying above 10,000 feet in elevation is for the most part well cleaned out. Near the main stream, however, considerable soil has accumulated and supports a forest

growth. *Roches moutonnées* occur at many points above 11,000 feet. Near the pass into the valley of Mineral Creek, at an elevation of 11,900 feet, striae on rock in place bear N. 47° W. Some lakes in rock basins occur, the largest being at 11,600 feet (Fig. 5). Near the margin of the valley the usual talus slopes are found, some of which have weathered until they support sufficient vegetation to give the slopes a covering of green; but for the most part

FIG. 6.—Part of the divide between cirque at head of Trout Lake branch of Lake Fork (on the right), and valley of Cascade Creek (on the left). Elevation of gap in lower central part of view, 12,700 feet. The surface of the glacial ice in the two cirques is believed to have been about up to the lower part of the gap.

the débris consists of apparently unweathered fragments. Fig. 6 shows the steep walls of a part of the southern boundary of the valley.

The eastern slope of the valley, including the tributary valleys from Poverty Gulch to the cirque-valley just above the village of San Bernardo, is steep, irregular in topography, and mostly covered with forest. *Roches moutonnées* occur at a few points, as in

Roger Gulch at 11,200 feet elevation, and in Ground Hog Gulch at 10,900 feet. Glacial drift including bowlders in variety, some of them striated, occur at numerous points, among which may be named: (1) Roger Gulch at 10,200, 10,600, and 10,800 feet; (2) Ground Hog Gulch at 10,500 and 11,100 feet; (3) south branch of Ground Hog Gulch at 10,800 and 11,500 feet; (4) Leslie Gulch at 11,000 feet; and (5) Poverty Gulch at 10,300 feet. Striations on bed rock occur on the south side of the stream draining Poverty Gulch at elevation 10,300 feet, bearing S. 73° W. It is therefore clear that glacial ice covered the whole eastern (westward-facing) slope; the irregularity of the topography is, however, in part due to landsliding, as noted by Cross.[1] The landslide here occurred partly before and partly after the more recent epoch of glaciation. Fig. 7 shows a landslide block which came to its present position before the more recent glacial epoch, as shown by the well-cleaned-out, round-bottomed valley head lying to the northeast of it, the steep walls above the talus, and glacial débris a little farther down the valley. It is in general true that the upper ends of the gulches on the slope here described are cirquelike, have well-cleaned-out, comparatively flat bottoms with occasional ponds, and are bounded by rough, nearly perpendicular walls rising above steep slopes of talus. Rock streams occur on the south side of Poverty Gulch at an elevation of 11,000 to 11,500 feet, and again a half a mile farther south on the other side of the ridge at an elevation of 11,500 to 12,000 feet. The broad cirque lying farthest east on the north side of Sheep Mountain has almost its whole surface below the precipitous bounding walls down to 11,500 feet elevation covered with bare talus slopes; below this a part of the surface supports a forest growth, which in turn gives way to a nearly perpendicular rock face southwest of the artificial lake at 10,000 feet elevation.

The slope south of Trout Lake, like that to the east of the lake, is mostly forest-covered but is less irregular in topography. Due south of Trout Lake, at 10,500 and 10,600 feet elevation, drift with striated bowlders occurs, and hummocky topography including occasional kettles continues to 11,000 feet. Striated bowlders also occur at 10,400 feet elevation southeast of Lizard Head Station.

[1] *Telluride Folio*, pp. 10, 11.

On both the east and the west sides of the central valley on the north side of Sheep Mountain is a medial moraine; on the east side the moraine extends from about 11,600 feet to 11,200 feet in elevation, and is for the greater part of the way a sharp ridge from 15 to 50 feet high; on the west side, the medial moraine is shorter and does not continue to be well marked below 11,400 feet. Besides the drift with striated bowlders already mentioned at 10,400 feet

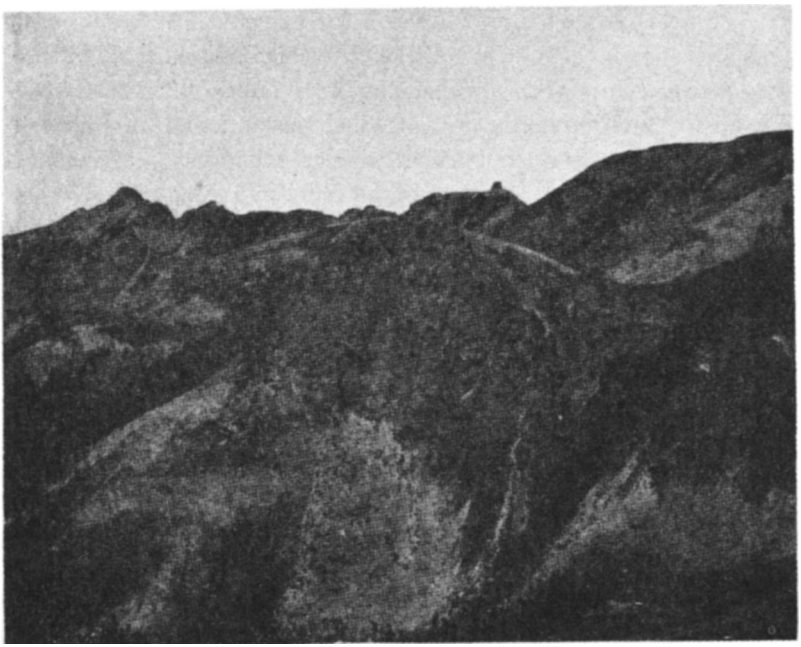

FIG. 7.—Landslide block of Potosi rhyolite, south of east from Trout Lake Looking north from 12,000-foot point one mile west of Pilot Knob. This block came to about its present position before the more recent glacial epoch.

elevation, the cirque northwest of Sheep Mountain contains deposits of bowlders in variety at 10,500 feet elevation west of the stream and at 10,800 feet more than a quarter of a mile farther east. Since the underlying rock here is shale, no *roches moutonnées* occur. Only the upper 500 feet of this valley is free from forests.

No ice entered the valley from the slopes of Black Face Mountain lying on the west. The upper margin of the ice west of Trout

Lake was a little less than 10,000 feet in elevation; the surface of the ice must, therefore, have had a general slope to the northwest of from 250 to 500 feet per mile, and the moraines about Trout Lake are to be considered as recessional, or as ground moraines.

Trout Lake is practically surrounded by moraines. Cross suggests[1] that the lake may be formed by a dam due to landsliding. While it is quite probable that there has been some movement in the material below the lake of the nature of landsliding, it is also true that so far as sections are exposed in the débris below the lake the deposit is shown to be typically glacial, consisting almost entirely of unstratified drift with bowlders in variety, many of them striated; and since the topography is also such as is found in morainal deposits, that is, irregularly disposed hills and ridges, it seems not inappropriate to class the deposit as morainal even though there may have been some readjustment of the materials since the ice withdrew. On the west and south of the lake there are distinct ridges of drift at several points trending in general in a north-south direction; but much of the surface is quite irregular. East of the lake, the moraine belt is narrow, extending to an elevation not more than 100 to 200 feet above the water's edge. To the southeast, morainal hills are found as far as the upper end of the artificial lake at 10,000 feet elevation. Southwest of Trout Lake they are continuous over the divide into the basin of the Dolores River, and extend up to about 10,400 feet. In this direction small kettles occur. Below the lake (to the north), the moraines continue for one-fourth to one-half a mile at nearly the same elevation as at the lower edge of the lake. Below this morainal dam, just north of the abrupt eastward turn of the railroad, the bottom of the valley is about 100 feet lower, some marshy areas occur, and the morainic hillocks are fewer and much smaller.

Just northeast of the village of San Bernardo *roches moutonnées* occur, and a few rods farther north a low recessional moraine extends from the railroad to the east side of the valley. Sections of this moraine exposed along the railroad show some stratified drift near the top and unstratified lower down, with bowlders in variety, some of them striated. The lower part of the valley just

[1] *Telluride Folio*, p. 10.

above the junction with Howard Fork is steep-sided, V-shaped, with outcropping rock on the east, and slopes covered with talus or soil on the west which, in places, supports a growth of aspen. This forest and the fresh accumulations of talus east of San Bernardo Mountain conceal such signs of glaciation as may have been present, except for occasional patches of bowlders, which, from their rounded and subangular forms and the variety of kinds present, are clearly of glacial origin.

The thickness of the ice in the neighborhood of Trout Lake and in the valleys above was probably on an average not more than 300 to 400 feet, with a possible maximum at some points of 800 feet.

VALLEY OF BILK CREEK

The upper part of the valley of Bilk Creek is double headed, with three small tributary cirque-valleys on the eastern side. Except for the small amount of loose material along the stream in the lower part, and the usual talus accumulations near the upper margins, this part of the valley is well cleaned out. Above 11,000 feet in elevation along the stream draining Bilk basin *roches moutonnées* occur at frequent intervals. At 11,200 feet is a small alluvial flat; below this the stream flows in a channel 100 feet deep at some points. At 11,800 feet and at 12,200 feet in Bilk basin, striae on rock in place have a direction approximately parallel to the course of the stream. At 12,000 feet, and at 12,700 feet, lakes or ponds are found in rock basins. Talus is abundant at the sides and heads of Bilk basin, and on the south side at 11,700 to 11,900 feet is a rock stream. From 11,000 to 11,500 feet in elevation the valley of the south branch of the upper part of Bilk Creek has a more gentle gradient and the bottom is in places marshy. Farther up are *roches moutonnées* and the usual boundary of talus slopes and precipitous rock walls. Abundant talus, partly overgrown with vegetation, flattened bottoms, and walls somewhat less precipitous than in typical cirques characterize the three cirque-valleys on the eastern side.

Magpie Gulch and the cirque lying next to the north contain little direct evidence of glaciation; enough, however, is present to make their occupation by ice certain. Within the lower, forest-

covered portion occasional accumulations of rounded and subangular bowlders in variety occur; in the upper portion, each has the flattened bottom and receding sides which distinguish glaciated cirques from the narrow, V-shaped valleys which were unoccupied by ice. At about 11,000 feet in elevation in the cirque north of Magpie Gulch, the topography is of the irregular form which may in part be due to landsliding. Above this, projecting points of rock in place show well-rounded forms, though no typical *roches moutonnées* occur. The usual long talus slopes and almost perpendicular rock walls form the upper boundary of the cirque. Magpie Gulch is quite similar in its general features; it has, however, a greater length, and contains a much greater accumulation of talus.

Below the mouth of the stream draining Magpie Gulch, glacial drift is present over the greater part of the surface of the valley of Bilk Creek and on the edge of the mesas on either side. In the lower part, however, for a mile or more above the junction of Bilk Creek with the San Miguel River, the drift is not conspicuous; for not only are the sides too steep, for the most part, to afford a place for lodgment for débris, but talus slopes at the base of the cliff faces have formed in post-glacial time, so that drift which may have been left on the less steep slopes nearer the stream has since been effectually concealed. Farther upstream the valley is broader and the products of weathering form alluvial cones and fans, especially on the west side of the stream. Beginning at a point about half a mile north of parallel 37° 55′ N., and continuing up the valley for four miles, glacial débris is in general abundant near the stream. At the lowest point in the tract just named, the débris is in the form of terraces on the east side of the stream, consisting of unstratified drift as far as observed, with bowlders in variety, some of which are striated. The terraces distinguished are two in number, their surfaces being 20 feet and 40 feet, respectively, above the stream Half a mile farther upstream, on the west side, stratified drift is exposed 100 to 150 feet above the stream. At elevation 9,000 to 9,100 feet morainal hills 40 feet in height occur on the east side of the stream. From this point well-marked morainal deposits, ranging up to 75 feet above the bottom of the valley, extend upstream

on the east side for about a mile and a half; in places the deposit consists of irregular hillocks; in places it becomes a distinct ridge near the stream. On the west side of the stream the moraine is not so well marked; in general, however, a somewhat flattened belt on the western slope corresponds in height to the top of the moraine on the eastern side. At 9,200 feet in elevation the steep slopes of the moraine lie on both sides of the stream. The well-marked morainal deposits do not extend above the alluvial flat lying between 9,200 and 9,300 feet.

The higher glacial deposits on the mesa east of Bilk Creek have already been described. On the edge of the mesa to the west, a forest growth obscures the deposit for much of the first two miles south of the San Miguel River; yet within this area at numerous points exposures of characteristic glacial deposits occur, including bowlders in variety. Farther south and continuing as far as the alluvial flat lying between 9,200 and 9,300 feet in elevation, the surface is covered with drift arranged sometimes as ridges, sometimes as irregular hillocks 50 to 75 feet high, inclosing numerous kettles. On the east side opposite the alluvial flat and for two miles downstream, the slope is shorter and steeper, and the topography is less irregular. One distinct ridge occurs, however, extending from about 9,400 to 9,800 feet in elevation, approximately parallel to the medial moraine already described, and lying about a quarter of a mile farther to the southwest. No distinct lateral moraine is found on the east side except for a short distance opposite Magpie Gulch at 9,900 to 10,000 feet elevation.

The maximum thickness of ice in the valley of Bilk Creek was probably about 1,000 feet.

VALLEY OF CANYON CREEK

That part of the valley of Canyon Creek included in the Telluride quadrangle is almost wholly free from glacial débris. *Roches moutonnées* abound, with striae in places. On the west side of the tributary heading west of Stony Mountain, at 12,000 feet in elevation, striae on bed rock bear N. 43° E. Cross has recorded striae near the Trust Ruby Mill along the north branch of Canyon Creek.[1] The topography of the valley as a whole is extremely

[1] *Telluride Folio*, p. 15.

rough and uneven in spite of the general absence of angular points and sharp lines which is due to the smoothing action of the ice. This impression is heightened by the sharp, rugged lines of the precipitous bounding walls. The summit of Stony Mountain is also very rough; it is, therefore, believed to have stood as a nunatak when the ice was at its maximum. Near the western side of the valley, two rock streams occur, one of which is shown in Fig. 8, and a little lower down, at 12,200 feet in elevation, a small lake in a rock basin.

The maximum thickness of ice in that part of the valley of Canyon Creek included in the Telluride quadrangle was probably not less than 1,500 feet.

CIRQUES NORTH OF DALLAS PEAK

The cirques lying northeast, north, and northwest of Dallas Peak were occupied by glaciers which extended northward to an undetermined distance. *Roches moutonnées*, lakes in rock basins, rock streams, talus slopes, and precipitous bounding walls are present here as in the other cirques of the region.

VALLEY OF DEEP CREEK—EAST FORK

In the cirques tributary to the East Fork, lying north of Iron Mountain and Campbell Peak, talus slopes and rock streams are the chief features. The opposite side of the valley has precipitous rock walls in places at the top, with talus slopes below, extending sometimes 1,000 feet down to the stream. Along the main stream, *roches moutonnées* occur at 10,400 feet in elevation on the south side of the stream, and at 11,000 feet elevation between the two cirques lying north of Iron Mountain.

At elevation about 9,700 feet on the west side of the stream, a small accumulation of glacial débris is found. It extends from the stream to the west talus slope, with its surface about 100 feet above the bottom of the valley. It consists of fragmental and rounded bowlders in variety up to 4 feet in diameter. Small depressions exist between this deposit and the talus to the west. No sign of a similar deposit is seen east of the stream at this point; but there is little opportunity for the lodgment of débris on the east side, as the

cliff bank is precipitous. This deposit extends for a distance of about 30 rods along the stream, and is interpreted as a recessional moraine. At its maximum, the ice in this valley extended to the point where the East and the West forks join, at an elevation of about 8,800 feet. The narrow tongue of ice in which this glacier terminated built a lateral moraine 150 to 200 feet in height and three-fourths of a mile long on the south side of this stream from

FIG. 8.—Rock stream northeast of Gilpin Peak at elevation 12,300 feet. Looking east from col at 13,000 feet. Lake partially hidden from view is in a rock basin. Potosi Peak (outside the Telluride quadrangle) is at center in the background.

elevation 9,500 feet to the west side of the West Fork, where bowlders in variety, some of them striated, mark the farthest extent of the ice. On the point between the two forks is an accumulation of glacial débris below the unglaciated point, and on the eastward-facing slope of the East Fork for half a mile above the junction, glacial débris is abundant; above about 9,500 feet in elevation the surface is covered for the most part with talus from

the steep slopes of the ridge west of the stream. Striae on rock in place occur at 9,300 feet elevation on the east side of the stream, with a direction approximately parallel to the valley's course.

The maximum thickness of ice in this valley was probably about 500 feet.

VALLEY OF DEEP CREEK—WEST FORK

The cirques which supplied the ice for the glacier in the West Fork of Deep Creek lie wholly to the north of the Telluride quadrangle. The glacial deposits in this valley are not in general well marked topographically. Glacial débris, including striated bowlders, occurs in abundance on the west side of the stream at an elevation of from 9,300 to 9,500 feet, and for nearly a mile farther down bowlders in variety appear occasionally at the surface. On the east side of the stream a deposit of glacial drift is found, beginning as a shelf at 9,600 feet, changing to the south into a ridge with a slight depression to the east, and extending to an elevation of 9,250 feet. This ridge contains bowlders in variety up to 6 feet in diameter. The lowest point at which drift occurs on the east side of the stream is at an elevation of about 9,000 feet, where it is found at distances ranging up to 60 or 70 feet above the bottom of the valley. In general, the western boundary of the glaciated area is not well marked, as the distinction along the lower part between the glaciated area near the stream and the landslide area to the west and southwest, east of Hawn Mountain, is not clear.

VALLEY OF PROSPECT CREEK

A small glacier of not more than 200 or 300 feet in maximum thickness occupied the upper portion of the valley of Prospect Creek. In the upper part of the valley rounded, projecting points of rock in place occur, and the appearance at the head of the basin is the same as in the other cirque-valleys of the region; that is, precipitous cliffs in a broad arc at the head with talus slopes below. The valley is broad and flat bottomed in cross-section, though having a steep longitudinal profile. In the upper part some ponds occur, together with several small, level, marshy areas, which are evidently the sites of former basins, now silted up.

In the half-mile just above the 10,500-foot line the surface on both sides of the stream is thickly strewn with large angular or

slightly rounded bowlders up to 15 or 18 feet in diameter. Below 10,500 feet in elevation there are few large bowlders; but rounded bowlders in variety occur down to 10,350 feet. Below 10,500 feet the north bank of the stream is steep and shows no sign of morainic topography; south of the stream, however, the surface is less steep and somewhat irregular. Striated bowlders were found at an elevation of 11,200 feet along the trail east from Bald Mountain, at

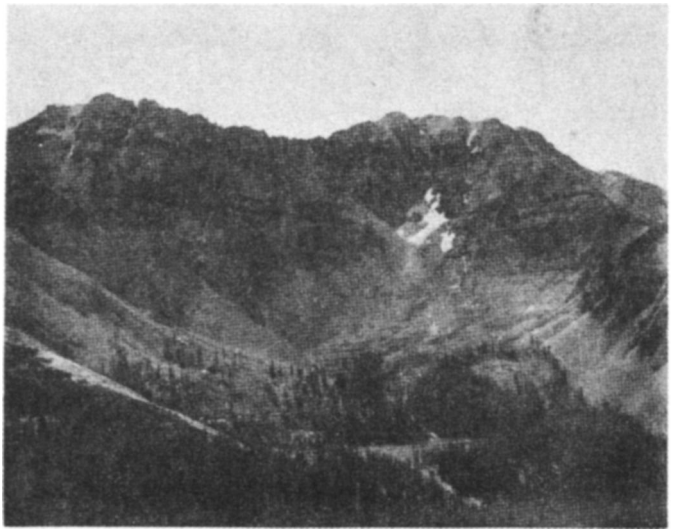

FIG. 9.—Turkey basin. Looking southeast from elevation 11,700 feet on Bald Mountain, about one mile distant. Note rock stream below patches of snow.

10,900 feet along the trail on the left side of the stream, and at about 10,400 feet on the left side of the stream.

VALLEY OF TURKEY CREEK

Turkey Creek is formed by the junction of a north and a south fork which drain Turkey basin and Alta basin, respectively. Turkey basin is a broadly open cirque, in general flat bottomed, though containing many low ridges and other irregularities of surface (Fig. 9). It contains three lakes, the largest of which has been increased in size by the construction of dams until it has a diameter of nearly a fourth of a mile. In the southeast part a rock stream

nearly a quarter of a mile in length is found at about 11,500 feet in elevation (Figs. 9, 10, and 11). Talus slopes on all sides, and high, steep, rock walls to the southeast form the boundary of the cirque. Alta basin resembles Turkey basin in its broadly open form, its abundant talus, and steep, high bounding walls. It differs chiefly in having a less level bottom, in the absence of distinct rock streams, and in the much smaller size of its lakes.

FIG. 10.—West edge of rock stream in Turkey basin. Elevation, 11,300 feet. Looking south. Note also the precipitous wall of cirque above talus slope in background.

Ice from Turkey basin and Alta basin spread over the plateau to the west, covering an area about two miles long by one and one-half miles wide. In this area outside of the cirques, below about 11,000 feet in elevation, the topography is that of ground moraine or terminal moraine; numerous irregular hills inclose kettles 10 to 15 feet deep and up to 100 feet in diameter (Fig. 12, and foreground of Fig. 2). In most directions this hummocky topography

continues to the margin of the glaciated area; on the north side, however, a distinct ridge extends for more than half a mile on the south side of Turkey Creek parallel to its course; and north of the stream, at the margin of the glaciated area, a low ridge lies across the valley of the small tributary heading northwest of Bald Mountain. To the southwest, the uneven moraine topography joins the scarcely less uneven landslide topography.

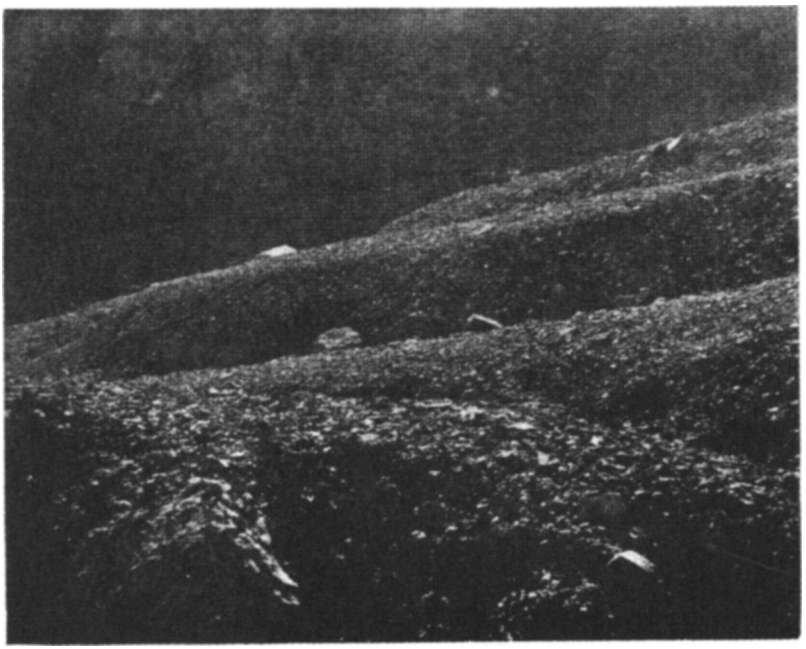

FIG. 11.—Detail of rock stream in Turkey basin. Elevation 11,300 feet. Looking east across north end of the moraine-like surface.

The maximum thickness of the ice in these two basins probably did not exceed 300 to 400 feet.

VALLEY OF BIG BEAR CREEK

Glaciers from the cirques north and west of Wilson Peak, respectively, united and extended down the valley of Big Bear Creek to about 9,300 feet in elevation. The valley of the cirque heading west of Wilson Peak lies, in part, outside of the Telluride quadrangle; its bottom is broad and less even than is the case in

many other cirques of an equal size. Prominent ridges extend from the head for a mile or more to the northwestward, making a series of small, almost parallel valleys in the bottom of the cirque. In each of these small valleys there are rounded projecting points, some talus, and occasional ponds or small lakes. Viewed from below, the slopes leading to the upper part of the cirque appear abrupt, and, in places, rough and precipitous. Below about 10,400

FIG. 12.—Surface of ground moraine, west of Alta basin. Elevation about 10,700 feet. Looking northwest.

feet in elevation the valley of that branch of Big Bear Creek which drains this cirque has prominent moraines. From 10,100 to 10,400 feet in elevation morainal hills are disposed irregularly across the narrow valley, including among them some kettles. On the west, from 10,300 feet in elevation a lateral moraine in places 100 feet high extends northeastward to the limit of glaciation, at about 9,300 feet. A similar ridge lies parallel to the stream on the east side from about 10,200 to 9,600 feet in elevation.

Eastward from these moraines for about two miles the ice spread in a broad sheet, leaving a hummocky, irregular topography. The line of farthest advance of the ice is sinuous, and not marked by any prominent ridges transverse to the valleys; kettles are more abundant, however, near the margin of the moraine than farther back to the south. At different points within the glaciated tract, short ridges of glacial débris with steep slopes occur; but the whole area is covered with a thick growth of spruce and aspen which not only obscures the topography, but often conceals the drift. However, the occasional exposures made by wash of streams, or in the construction of irrigation ditches, furnish abundant evidence of the character of the surface deposits.

An outwash plain of gravel and bowlders extends for about a mile below the edge of the glaciated tract on the east side of the west branch of the stream, having a thickness of from 20 to 30 feet.

The cirque lying north of Wilson Peak resembles closely the one lying next to the east, already described (p. 619). It is broad, shallow, and with unusually high, precipitous walls. As in the cirques just to the east, the underlying rock weathers readily, and *roches moutonnées* and exposed striated rock in place do not occur.

The maximum thickness of the ice was undoubtedly greater in the cirque west of Wilson Peak than in the one to the north, and may have reached 700 or 800 feet.

NAVAJO BASIN AND THE TWO VALLEYS NEXT SOUTH

These three valleys were occupied by glaciers which extended to an undetermined distance beyond the limits of the Telluride quadrangle. That part of Navajo basin included in the Telluride quadrangle is, with the exception of long slopes of talus, almost perfectly cleaned out. *Roches moutonnées* are abundant in the bottom, giving a smooth, regular appearance to the slopes as viewed from the upstream side. As in other cirques, when viewed from the downstream side, a succession of steep slopes appears with some low, rough, precipitous walls.

The cirque next south of Navajo basin is in all essentials like others at equal altitude. The valley is, however, much narrower than Navajo basin, and the talus slopes lying at the foot of the high

bounding walls meet at some points, producing the effect of a valley less well cleaned out. The bottom shows the same alternation of steep and gentle slopes as is found in other cirques.

The second valley south of Navajo basin heads in a shallow, double-headed depression on a steep southern slope. At about 12,500 feet in elevation the generally steep slope is flattened into a shelf or bench perhaps 20 rods in width; back of this shelf the rock wall rises with a steep slope, and on the east and west are short side walls. Below this shelf, talus slopes divided in the middle by a north-south ridge extend down to a second more nearly level area between 11,500 and 11,800 feet in elevation; the topography on this shelf is irregular, and the surface is overgrown with low plants. Below this, steep, rough-faced cliffs appear, at the base of which the more level bottom of the valley begins. The underlying shale is here deeply weathered and eroded in places, showing bare ridges and gullies with but little glacial débris. Farther down the valley, however, glacial drift covers the surface, and a little beyond the edge of the quadrangle typical morainic topography occurs, viz., kettles inclosed by irregular hills containing bowlders in variety, many of which are striated.

At elevation 11,200 feet on the eastern side of the valley glacial drift including bowlders in variety up to 8 feet in diameter forms a ridge extending in a northeast-southwest direction for more than half a mile. The southeast slope of this ridge is gentle, grading off gradually into the unglaciated area; the northwest slope descends to the valley 100 feet or more at an angle of 30° to 35° with occasional exposures due to recent erosion or landslides. This ridge, therefore, constitutes a lateral moraine, the elevation of whose crest above the bottom of the valley is due in large part to the erosion of the underlying formations in which the stream has cut its valley.

The maximum thickness of the ice in Navajo basin and in the valley next south was probably not less than 1,500 feet; in the second valley south of Navajo basin, probably not more than 400 feet.

VALLEY OF KILPACKER CREEK

The cirques at the head of this valley are free from glacial débris. The broader one to the east is cut wholly in a formation of

shale traversed by dikes of igneous rocks. The shale is in places eroded into deep gullies (Fig. 13), leaving bare, gray slopes; in other places landsliding has occurred, resulting in ridges lying

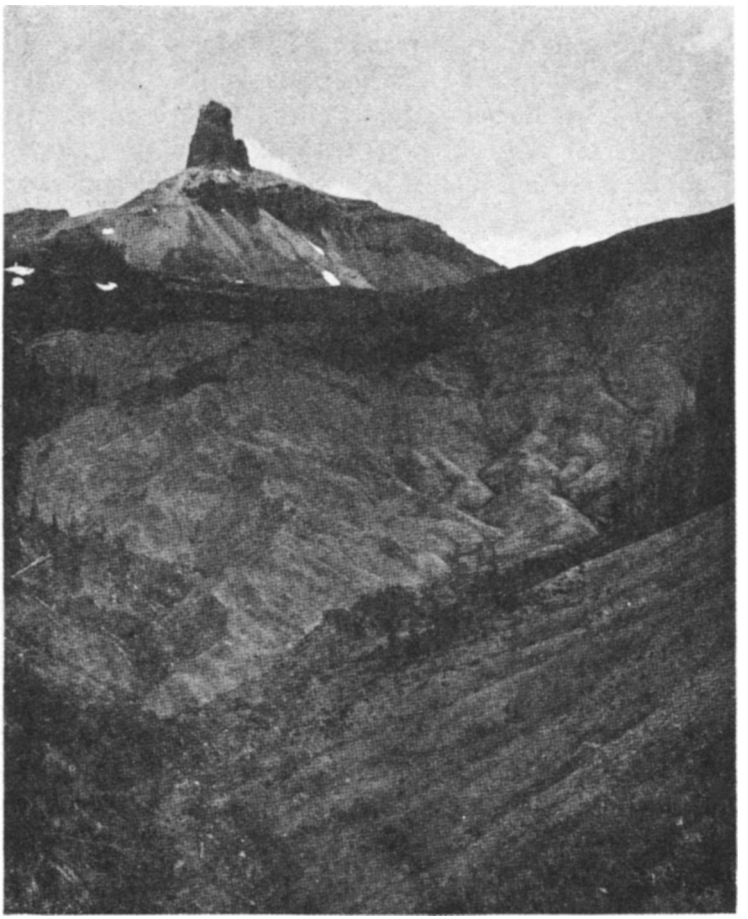

FIG. 13.—East branch of Kilpacker Creek; eroded, bare Mancos shale in center; elevation about 11,300 feet. Lizard Head Peak in background. The eroded floors of cirques with shale as the underlying formation contrast strongly with the *roches moutonnées* of cirques formed in harder rocks.

approximately parallel to the slope, inclosing undrained depressions. The two small cirques near Mt. Wilson have a steep gradient, and

contain some rounded projecting points of rock in place with abundant talus.

From about 11,000 to 10,800 feet in elevation a lateral moraine more than half a mile long lies about a quarter of a mile west of the stream. On the eastern side opposite, there is no distinct ridge of drift, but the somewhat steep slope shows glacial débris at many places. At 10,900 feet in elevation in the bottom of the valley, a small alluvial flat is found, evidently due to the silting-up of a pond. Southwest of this flat the side of the valley is in some places too steep for débris to lie; in other places it is more level, and irregular hillocks inclose kettles. Near the western edge of the glaciated area some landsliding has occurred. In the lower part of the glaciated area abundant glacial débris conceals the bed rock at most points and extends to a height of 300 feet above the stream; bowlders up to 5 or 6 feet in diameter are found, many of them well striated. In the lower half-mile of the glaciated tract the topography of the drift is quite irregular, hough some ridges subparallel to the stream occur, as well as a less number of shorter transverse ridges. The lowest point reached by the ice in this valley was at an elevation of about 10,150 feet. Maximum thickness of ice, about 500 feet.

VALLEY HEADING SOUTH OF LIZARD HEAD PEAK

The small cirque lying south of Lizard Head Peak is cut in shale, and its upper part has no glacial drift. The more level part of the cirque ends at about 11,500 feet in elevation; below this for about a quarter of a mile the gradient is steeper and the stream flows for a part of the way in a canyon having for its right wall a precipice of igneous rock, in places 75 to 100 feet high, and for its left wall a steep talus slope.

The lower limit of glaciation in this valley was a little below 10,200 feet in elevation. At this point is a broad transverse ridge of drift 10 feet high, extending from the stream eastward for 100 yards. Another similar transverse ridge, perhaps 15 feet high, occurs 20 rods farther upstream. The slopes of the valley are covered with drift up to 200 or 300 feet above the stream; the deposit on the west side of the stream is apparently more abundant

than on the east, and is partially arranged in ridges approximately parallel to the stream's course.

The maximum thickness of ice in this valley was probably not more than 300 feet.

VALLEY OF WILSON CREEK

The glacier which occupied the valley of Wilson Creek was in the shape of a crescentic sheet concave toward San Bernardo Mountain. A short morainal ridge southeast of San Bernardo Mountain at 10,700 feet to 10,800 feet in elevation marks the lower limit of the ice to the east. Northward, down the valley of Wilson Creek, the ice extended to nearly 10,200 feet in elevation, crossing the stream at this point; above this point is a lacustrine flat which extends for nearly a mile along the stream.

Above timber line to the west are the accumulations of talus and precipitous rock walls usually found in glacial cirques in this region. On the south the slope north of Black Face Mountain is mostly free from talus; some points are smoothed as if by the action of ice, but over most of the surface a thin covering of soil scarcely concealing the rock in place supports a growth of low plants. No precipitous wall is found on the south; the valley slope gradually flattens at the top to form the rounded crest of the ridge, which on its southern side is steep and furrowed with V-shaped gullies. Southeast of San Bernardo Mountain, above the short moraine already mentioned, the glacial deposits show an uneven surface at a few points, inclosing two or three ponds. On the west side of the valley north of east from Lizard Head, a morainic ridge at 10,800 feet in elevation extends for a quarter of a mile in a north-south direction. Over most of the area, however, the surface is irregular.

The lower slopes of the valley on both sides of the stream above the flat are heavily wooded at most points, obscuring to some extent both the topography and the composition of the surface deposits. At numerous points on the eastward-facing and northward-facing slopes, however, glacial drift is exposed, including bowlders in variety, some of which are well striated. In this respect these slopes are in sharp contrast to the southward-facing and westward-facing slopes of San Bernardo Mountain, where rock fragments are

rare, shale exposures abundant, and topography due to landsliding often clearly evident.

The maximum thickness of ice in this valley was probably not more than 200 to 300 feet.

VALLEY OF THE EAST DOLORES RIVER

Glacial ice descended the valley of East Dolores River to an elevation of 9,550 feet. Ice was continuous from this point up the north branch over Lizard Head Pass, up the main valley to the cirques south of Sheep Mountain, and to the top of Flat Top Mountain. Southwestward from Lizard Head Pass, two lacustrine flats mark the position of silted-up lakes. Over most of the remaining surface up to 100 or 200 feet above the stream, glacial drift is abundant. At no point in the Telluride quadrangle was drift found containing a larger proportion of striated bowlders than along the north side of this valley below Lizard Head Pass. The topography on the south side of the stream is more uneven than on the north, but a forest growth has made the determination of the composition of the surface deposits more difficult. The 10,200-foot hill lying in the valley a mile and a half below the pass has a core of igneous rock overlaid by drift. At the point where the stream changes its course to nearly due south, rock in place is exposed on the west side of the stream and drift is not abundant. On the east side, however, morainal hills continue to the junction of the two branches of the stream.

The upper boundary of the glaciated area on Flat Top Mountain is a 25° to 30° slope of bare shale 40 to 50 feet high, extending in an east-west direction for about half a mile. This steep, northward-facing slope lies a little south of the southern boundary of the Telluride quadrangle. From 11,800 to 10,500 feet in elevation *roches moutonnées* are abundant, and in many places show striae bearing northeast of north, in general parallel to the course of the stream. To the northeast, the northwest, and the west, lobes of ice extended to the edge of the steep, precipitous slopes of igneous rock. Along the valley to the northwest, down to about 11,000 feet in elevation, *roches moutonnées* and striae are abundant. The valley leading northward to the Dolores River is a broad ravine in

its lower part, with morainal deposits below about 10,500 feet in elevation. On the east side of the valley a distinct lateral moraine extends from about 10,400 to 9,800 feet elevation, the upper end being farther from the stream than the lower. On the west side a morainic ridge extends from about 10,000 feet in elevation down into the valley of the Dolores River. The glacier on Flat Top Mountain probably did not exceed 200 feet in thickness at the maximum. Its action was not vigorous, and probably only a small portion of the whole mass of ice reached the valley of the Dolores River.

The source of the largest amount of ice entering the valley of the East Dolores River was in the cirques south of Sheep Mountain. Above 12,000 feet in elevation the cirques show the usual variations in gradient, some cliffs from 60° in slope to perpendicular, some slopes more gentle, 10° to 20° with irregular topography due in part to weathered heaps of talus, in part to irregularities of the rock floor. Back of the last more level portion are the slopes of bare talus and the precipitous bounding walls. Below 12,000 feet in elevation the rock in place is largely obscured by weathered rock waste and glacial drift which in places supports a considerable forest growth.

At the point where the stream draining the two cirques enters the East Dolores River, drift hills are abundant on the east side of the river. The edge of the ice here pushed up the valley of the East Dolores to the south for a half a mile, leaving a moraine at 10,250 feet in elevation with its top 30 to 40 feet above the stream. For nearly a mile and a half on the north side of the stream draining the two cirques drift hills cover the slope up to about 500 feet above the stream. In some places the topography is irregular, but more often there are more or less distinct ridges, either approximately parallel to the course of the stream, or tending to become oblique by an approach of the ridge to the stream in the downstream direction. South of the stream the drift hills continue up to about 10,600 feet in elevation. In the drift on both sides bowlders occur in variety, many of them striated. Above the well-marked drift hills, frequent accumulations of glacial débris, in some cases inclosing undrained depressions, continue for a half a mile or more.

In the valley of the East Dolores northeast of Flat Top Mountain drift is abundant on both sides for half a mile or more above the junction of the two branches. Farther upstream, on the west side, the surface is almost wholly covered with talus from the precipitous outcropping igneous rock. On the east side drift is found near the stream below the outcropping cliff face, and in places on the more level area above the outcrop. The westward-facing slope for more than a quarter of a mile above the boundary as determined for the more recent stage of glaciation contains evidence of the presence of ice of an earlier epoch. The line of division between these two areas is, however, drawn somewhat arbitrarily, its position being determined in part by a comparison of the elevations of the limit of recent glaciation at points respectively farther up and farther down the valley. As finally determined the line represents approximately the line of division between abundant drift on the surface (recent epoch) and occasional, disconnected patches of drift (earlier epoch).

The drift hills near the junction of the two branches are, in general, irregular in arrangement, and less prominent below the junction than above. On the north side, however, at 9,900 feet elevation, a distinct lateral moraine occurs extending for 40 rods in a northeast-southwest direction. Lower down on the slope at 9,700 to 9,800 feet elevation is another fragment of a morainic ridge parallel to the one first named. These ridges are distinguished as morainal from somewhat similar ridges and terraces farther up the slope which are due to landsliding, chiefly by their composition, but also by their greater length and regularity. The lower limit of extent of the ice is marked only by small accumulations of drift on the somewhat steep slope. Below this point valley train deposits occur west of the mouth of Kilpacker Creek and again at various points on the south side of the stream up to 30 feet above the bottom of the valley.

The maximum thickness of ice in the valley of the East Dolores was probably about 500 feet.

VALLEY WEST OF GRIZZLY PEAK

That part of the head of the cirque lying northwest of Grizzly Peak on the north side of the stream presents the same features as

the cirques lying south of Sheep Mountain. The slopes on the south side of the stream, however, and the ridge bounding the valley on the south are distinctly different. These slopes are covered with bare talus and show an uneven, hilly topography due to the weathering of numerous irregularly disposed bosses of outcropping rock. The rock in place is completely mantled with angular fragments, and on the west and northwest sides of Grizzly Peak the long, steep talus slopes extend practically to the summit of the mountain, giving to this part of the cirque an appearance which contrasts sharply with the usual precipitous walls which bound most of the other cirques.

Glacial ice of the more recent epoch extended down to about 10,700 feet in elevation. At this point the glacial deposits are best preserved on the north side of the stream, where drift hills 150 feet high show a slope of about 30° both to westward and to southward. For about half a mile eastward on the upper part of the slope on the north side of the stream, drift occurs containing bowlders up to 8 feet in diameter, some of which show striations. Drift with striated bowlders also occurs on the south side of the stream, but a small tributary not shown on the topographic sheet either has prevented the deposition of as large an amount, or has carried away much of what was deposited. The lower part of the glaciated area, up to about 11,500 feet in elevation, is mostly forest-covered. The topography is irregular, with some undrained depressions.

The maximum thickness of ice in this valley was probably about 300 feet.

CIRQUE-VALLEYS TRIBUTARY TO THE ANIMAS RIVER

All the cirques and valleys lying in San Juan County in the southeast part of the Telluride quadrangle are drained by tributaries of the Animas River. With the exception of deposits on the north side of the stream eastward from Ophir Pass and in the lower part of the valley next south, where drift hills with striated bowlders occur up to 400 feet above the stream, these valleys and cirques are all practically free from glacial débris (Fig. 14). In general, abundant talus covers the slopes at the base of steep cliffs, while on the more level portions more or less well-developed *roches moutonnées* are found. In many places the rock in place weathers

too readily to allow striae to be preserved, yet at the following points excellent examples are to be seen:

1. Southeast of Rolling Mountain on the northward-facing slope, numerous striae parallel to tributary streams; average bearing about N. 7° W.

FIG. 14.—Cirque three-fourths of a mile north of Grizzly Peak, tributary to valley of Cascade Creek. Elevation 12,500 to 13,000 feet. Looking south of west from southward-facing slope at head of valley of Cascade Creek.

2. Southward from this slope along the trail over the pass into the valley tributary to Cascade Creek, at 12,500 feet elevation, bearing N. 77° W.

3. South of Twin Sisters Mountain, one-half a mile from the south boundary of the quadrangle, at 12,000 feet elevation, bearing S. 77° E.

4. East side of pass along the trail leading from the Trout Lake branch of Lake Fork to the South Fork of Mineral Creek, at elevation 12,000 feet, bearing S. about 75° E.

5. In the upper part of the valley of Mill Creek, at 12,500 feet elevation, three-fourths of a mile from the eastern boundary of the quadrangle, bearing nearly due east.

Lakes and ponds in rock basins, most of which are of sufficient size to be mapped, occur in the following valleys:

1. Valley of Lime Creek southwest of Twin Sisters Mountain, at an elevation of from 12,000 to 12,500 feet.

2. South Fork of Mineral Creek south of Beattie Peak, at 11,500 to 12,000 feet elevation.

3. Ice Lake basin, at 11,500 to 12,800 feet elevation.

4. Clear Lake, one mile east of U.S. Grant Peak, at 12,000 feet elevation.

5. East of Ophir Pass, at 12,000 feet elevation.

6. Mill Creek basin and cirque next south, at 12,000 to 12,500 feet elevation.

Rock streams are found in the south part of Paradise basin, and to the north and west of Twin Sisters Mountain. In the valley of Cascade Creek at 11,200 feet elevation a small alluvial flat occurs such as is due to the silting-up of a pond or lake.

The maximum thickness of ice in these valleys was in the South Fork of Mineral Creek where it must have reached more than 1,500 feet; the maximum in the valley of Cascade Creek was probably not much less.